MDE Product Development Team
FY14 Quarter 1 (October-December 2013) Report
Correction **Submitted 16 January 2013**

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(Compiled and edited by S. Benjamin and B. Johnson)

Executive Summary

Task 1: Improve turbulence guidance from NWP forecasts

- **RAPv2 field test successfully completed,** Configuration Control Board of NCEP/EMC approves RAPv2 for **implementation**, **now scheduled for late February 2013.**
- RAP/HRRR presentation made by GSD to annual NCEP Model Production Suite Review, available at **http://ruc.noaa.gov/pdf/NCEP_PSR_2013_RAP_FINAL_v5.pdf**
- Important name list change to procedure for defining initial fields in WRF was determined and added to RAPv2 to improve model robustness with no overall impact on forecasts.
- A correction to radar reflectivity flags for RAPv2 was made to distinguish between no-echo and no-data.
- RAPv2 version run by ESRL was updated with the boundary-condition name list change and continues to run smoothly on Jet (Boulder, RAP primary cycle) and Zeus (Fairmont WV) supercomputers and initializing experimental HRRR.
- Three real-time parallel RAP cycles (with extensive verification of each toward RAP version 3) running on Zeus to evaluate further likely enhancements to RAP data assimilation / model system for spring 2014 code freeze.
- NCEP making continued progress on NAM and NAM-nest
- Testing to optimize parameter setting for hybrid ensemble data assimilation in RAPv3 for Spring 2014 code freeze

Task 2: Improve Quality of Convective Weather Forecasts from RAP, HRRR, NAM, NAM-nests and, eventually, NARRE and HRRRE

- Complete HRRR code transferred to EMC and tested by GSD on NCEP WCOSS computer, good progress toward building EMC real-time parallel test system with implementation now expected late Q3 FY14
- MRMS 15-min radar data now available on WCOSS development machine for NCEP-real-time HRRR 3-km testing
- Hourly and 15-min RTMA surface analyses running in real-time with grids available on ftp for external users

Task 3: Improve Quality of Icing Weather Forecasts from RAP, HRRR, NAM, NAM-nests and, eventually, NARRE and HRRRE

- Testing of RAPv3 with WRF v3.5.1 with new shallow cumulus and an updated MYNN PBL scheme and updated versions of the Grell-3D and Grell-Freitas cumulus scheme in RAP real-time parallel runs yielding encouraging results. These changes are now in parallel testing in RAP-dev2 version at GSD, with implementation expected in RAPv3 (in ESRL in Mar 2014 and at NCEP in winter 2014-15)
- RAPv2 updated physics configuration continues to run in both RAPv2 at GSD and in parallel cycle on WCOSS machine at NCEP [MYNN boundary-layer scheme (Olson version), 9-level PBL, updated Thompson microphysics, others]

Task 4: Develop convection-ATM-specific improvements to guidance from the HRRR (and later, HRRRE) and interact with CoSPA (or other) program partner labs and the FAA

- Real-time, frozen RAPv2/HRRR system continues to run successfully with gridded field dissemination into winter 2013-14 although CoSPA officially shut down on 1 Nov 2013.
- HRRR “failover” capability to use feed from Zeus instead of Jet during Jet downtime continued to work.
- GSD plans for HRRRv2 follows physics changes for RAPv3, and a plan to be implemented on Jet and Zeus by early April 2014 and at NCEP in early 2015.

Task 1: Improve turbulence guidance from NWP forecasts

Improving turbulence forecast quality involves efforts to improve initial conditions for the RAP and NAM (and HRRR and NAM Nest models) and to improve the models (WRF-Advanced Research WRF (ARW)-RAP and NOAA Environmental Modeling System (NEMS)- Nonhydrostatic Multi-scale Model – B (NMMB)).

Tasks will include:

- Continuing evaluation of RAPv2 toward early 2014 implementation at NCEP, incorporating changes developed in 2012 and early 2013
- Development of RAPv3 toward 2014 implementation at ESRL and subsequent implementation at NCEP
- Collaborating on developing and testing best approaches for use of hybrid/EnKF/3DVAR data assimilation within common GSI coding structure.

ESRL

Regarding the operational NCEP RAP

The operational RAP (RAPv1) ran without any technical problems, including in the post processing, through the October-December quarter.

Progress toward RAPv2 implementation at NCEP
After good progress during October, the 30-day field test for the RAPv2 began at 12z 5 November. To cut to the chase, after some unexpected crashes at NCEP in November and as late as 26 December, a specific boundary-condition problem related to a WRF name list parameter was discovered and solved in late December. Culminating a GSD team effort, Tanya Smirnova discovered on 29 Dec that the default option (hypsometric_opt in the WRF-ARW name list) for the specific formulation of the hydrostatic equation used to define the initial conditions prior to the start of the forecast (and the lateral boundary conditions during the forecast) had been changed from 1 to 2 when WRFv3.4 was released. When hypsometric_opt was restored to the old default option 1, all the crash cases, including the November cases along the lateral boundaries, ran successfully. This was pointed out to the NCAR WRF developers, who then initiated their own investigation and found a serious bug in the new option 2 default formulation. With this bug removed, both old and new options ran successfully. GSD subsequently conducted a short retrospective experiment comparing results between use of hypsometric_opt = 1 and (corrected) hypsometric_opt = 2, and obtained essentially identical forecasts.

Prior to this change to the hypsometric_opt WRF parameter (the real solution), GSD also designed and implemented a smoothing to terrain elevation near the lateral boundary in November. While this temporarily increased robustness of the RAP, it turned out to not be addressing the central problem. These terrain elevation changes have been retained in RAPv2.

The quick discovery that the true source of all the crashes was fixable by a one-line name list change, its quick introduction by Geoff Manikin into the NCO RAP on 30 December, and documentation by GSD that the impact of this change was also very minor, permitted the field evaluation of the RAPv2 to be completed, and on 9 January the Storm Prediction Center, Aviation Weather Center and National Weather Service regions all gave the go-ahead for implementation. However, for the sake of ensuring the reliability of the RAPv2 functionality in operations together with a last minute elimination of a spurious unneeded diagnostic product, implementation of the RAPv2 has now been rescheduled for sometime in the 18-25 February period.

The RAP web page **http://rapidrefresh.noaa.gov** was updated with latest information on the planned RAPv2 implementation. A link to the RAPv2 Technical Implementation Notice was added there also. A webpage on RAP output grids from NCEP was updated at **http://ruc.noaa.gov/rr/RAP-NCEP-output-grids.html**.

GSD (Haidao Lin) has carried out a significant study on the impact of radiance bias correction for the Rapid Refresh. When implemented, this change will allow the RAP to use satellite radiances more effectively by removing any expected biases by tracking previous biases on a channel-by-channel basis. This report will be included in the next MDE monthly report.

RAPv3 model testing

- With the release of WRFv3.5.1 by NCAR on 23 September, Tanya Smirnova began work toward merging the unique RAP features at the top of the GSD WRFv3.4.1 trunk to v3.5.1. This went fairly smoothly, and the RAP-dev2 and dev3 on Zeus have been running with this version since 21 October.
- Revision and evaluation of the Grell-Freitas and more recent version of the Grell-3D convective scheme and their related shallow convection scheme continue (see Task 3). This includes both real-time evaluation and evaluation using summer retrospectives.
- Tanya Smirnova continues to investigate changes to the RUC LSM relating to surface roughness length over snow (see Task 3) and modifications to the snow building and trimming algorithms based on the daily NOAA Ice Monitoring System snow coverage. A modification to snow building that is more restrictive regarding areas where snow is built, but builds more snow cover in these areas has been introduced into RAP-dev3 for evaluation.
- Associated with this, without artificial augmentation (snow building), snow cover in much of the western US is deficient in RAP, leading to both analysis and forecast errors for temperature. Deficient snow cover is related to poorer radar coverage over the West due to fewer radars, often-severe blockage of the radar beam by terrain, and shallower precipitating clouds in winter, further limiting the ability of radar to see current precipitation. Modifications to the hydrometeor analysis to better account for volumes of atmosphere where radar data is unavailable, and to give more weight to the 1-h forecast hydrometeors in these volumes are under consideration.
- Joe Olson introduced a change to the MYNN surface layer intended to reduce RAP nighttime cold bias in 2-m temperatures over snow cover.
- New precipitation-type verification is being tested with retrospective and real-time RAP and HRRR output. Also, an NCEP w3lib routine was adapted to correctly transform RAP horizontal native grid output to the Alaska Grid 242 (Polar Stereographic) for verification purposes.

Other activities, some noted more fully under other tasks, also were undertaken:

- Retrospective testing for both RAP and HRRR of the impacts of proprietary in situ tower wind data and other special data under funding from the DOE Wind Forecast Improvement Project was concluded and a report is being written for DOE.
- Discussions with EMC continue concerning the best procedure to ensure that proprietary wind tower and nacelle wind measurements are available to the operational RAP and NAM now that WCOSS has come online.
- Quasi-biweekly telecons between GSD and the Storm Prediction Center of NCEP continue to be very beneficial. The purpose of these telecons is to obtain feedback from SPC on RAP (RAPv2 from GSD as well as the operational v1) and GSD HRRR-primary performance, to give SPC opportunity to comment on our ongoing RAP and HRRR development work, and to inform SPC of planned Jet and Zeus computer downtimes.
- On 18 November representatives from General Dynamics, ESRL and NCAR/RAL met to discuss a report on probabilistic (convective) weather forecasting and related air traffic management decision-making prepared by General Dynamics.
- Stan Benjamin, Steve Weygandt, Curtis Alexander, Ming Hu and Haidao Lin attended the annual NCEP Product Suite Review held at NCEP on 5-8 December. Steve, Curtis, and Stan made a presentation on the RAP, HRRR and FIM. This presentation is available at **http://ruc.noaa.gov/pdf/NCEP_PSR_2013_RAP_FINAL_v5.pdf**
- This NCEP visit provided opportunity for productive face-to-face discussions with NCEP scientists on a variety of topics, including EnKF hybrid data assimilation and NCEP access to the MRMS (multiple radar multiple sensor) products produced by the NOAA National Severe Storms Lab (these products are now ftp'ed in real time from NSSL by NCEP), making available the 15-min reflectivity data necessary to run the HRRR 1-h pre-forecast cycle on the WCOSS machine).

NCEP

NCO built their real-time RAP parallel in October in preparation for a December implementation. The model, unfortunately, experienced a series of crashes in November and December. The first involved a strong system on the southern boundary in South America; the second set was associated with a system near the northern boundary in Greenland interacting with an intense terrain gradient in that vicinity. In each case, a fix was developed, tested and given to NCO, and the 30-day IT test was restarted. The first fix set the terrain values at the model boundary equal to the points of the second row. The second fix provided a new topography field with smoothing over Greenland. Since these model issues were along the boundaries of the model domain and had no impact on the CONUS, the scientific evaluation of the RAP was not affected. Another crash occurred near the end of December, associated with an intense oceanic storm near the northeast corner of the domain. This crash was definitively linked to a change made in the WRF code (the newest WRF

core) to change the way that a key equation is solved when rebalancing the boundaries. The RAP was changed back to the old method of solving this equation on 30 December and the IT test restarted. It is again believed that the largest impacts of this change are confined to the boundaries and that a restart of the scientific evaluation is not required. An EMC Change Control Board will review this finding in early January. Testing is also ongoing to see if the earlier crashes can also be linked to this issue. Implementation is targeted for the middle of February, after the IT test period is completed. (Geoff Manikin)

The Dumps and Satellite Ingest pieces of the Observation Processing suite are being put into SubVersion/Vertical Structure/Equivalent Environment now required of all implementations on WCOSS. This is being done to allow NESDIS to provide hourly atmospheric motion winds, which will be used in RAP and NAM. Work and implementation is expected to finish next month. (Dennis Keyser)

A new project was started that will eventually impact large parts of the GSI code, with the goal of making GSI more scalable. Most users of GSI are now running into the problem that for high-resolution models or for very large domains or both, the code begins to use too many resources on current and future parallel machines. This is the case for the upcoming global GFS T1534 implementation [and possibly for the HRRR]. The global analysis grid for the T1534 upgrade package is being kept at T574 to fit things in, and the ensemble-Kalman-Filter part is only being increased from T254 to T574. Ideally, these would be much closer to T1534. (Dave Parrish)

Assistance was provided to NCO to set up the official RTMA evaluation parallels for the Q2FY14 RTMA upgrade and a draft Technical Implementation Notice was provided. A poster on the RTMA "smart observation quality control" was presented at the 6th WMO Symposium on Data Assimilation, College Park, Maryland. Work on splitting the GSI-RTMA control variables into land and water components has been completed. The main goal is to improve the land/water contrasts in the analysis. The use of an enhanced prepBUFR file that uses new report types for observations lacking a surface pressure report has been successfully tested in the RTMA. Discussions have been carried out with team members from the Sandy Supplemental Blender project on needed enhancements to the RTMA, including the use of a multi-model blended first guess, and improved observation quality control. In that regard, a list of the current RTMA weaknesses has been compiled and shared with the group. Work has been initiated on developing a python-based package to plot the RTMA analysis and observations with zooming-in capability. (Manuel Pondeca, Steve Levine, Yuqiu Zhu)

An ensemble tool for member clustering was modified in October to keep "time continuity" in each cluster and was delivered to NCO for its implementation into the operational SREF. The SREF interim upgrade package was transitioned to the operational environment and a parallel began running daily in real time on November 22. The scheduled implementation date for this upgrade is in February 2014. (Jun Du)

In response to a request from the Chicago WFO, the NRRRE-TL web page was upgraded in October to keep two days of plots so that users can see previous day's evening forecast results from NARRE-TL site. The NSSE experimental web site was maintained; the new HiresW WRF parallel for the CONUS was added to the NSSE. (Binbin Zhou)

The REF2GRB package was upgraded to generate 3D reflectivity mosaic in grib2 format, and is in testing. Efforts are underway to generate the 3D reflectivity product with a 15-minute interval. Three new BUFR files were added to test reflectivity assimilation with GSD's cloud analysis package, and validation is ongoing. A parallel run (NAMREF) for assimilating radar reflectivity was set up on WCOSS, and NAMREF forecasts were compared with the NAMX parallel. Short-term precipitation forecast skill is improved. Modifications to GSD's cloud analysis codes for NMMB added to the GSI repository and some code details were modified and tested. (Shun Liu)

The off-line GSI parallel for satellite bias correction was upgraded to include GFS spectral IO modifications to decrease the amount of memory used. Since the global ensemble used by the NDAS regional hybrid analysis will increase in resolution, the spectral IO needs to be more efficient to run on the new Linux-based supercomputers, which have less memory per core. These fix files were updated to those used in the global parallels with the new satellite bias correction scheme. The verification statistics of the impact study on the new satellite bias correction scheme were calculated and the impact was neutral. The scripts and initial satellite bias coefficients for the new correction scheme were prepared and added to our official parallels. A new project to add ability to the GSI to assimilate wind speed and direction instead of U and V was opened, to assimilate observations as close as possible to the original observed quantity so an uncontaminated observational error variance can be defined. The GOES hourly visible winds were checked and monitored in the NAM parallels and GSI run times tuned. A fix file was changed to use the satellite wind properly with the latest changes in data subtypes. The 24-hour data counts used in the NDAS operational and parallel systems were calculated, and new satellite bias correction and QC scheme reduced the amount of data used. A parameter to tune the

coefficients for the hybrid variational-ensemble used in the regional was added to the GSI and an off-line NDAS test was performed to complete the tuning needed for the changed resolution of the input global ensemble. A positive impact was found and the tuning will be added to the next package. Work began to use the new RTMA diurnal reject lists along with GSD's cloud analysis in the NDAS parallel. A GSI change to use station height to place surface observations with bad observational pressure is in progress, and QC flags will be changed to allow the data to be used. (Wan-Shu Wu).

CAPS

During December 2013, CAPS ran more dual-resolution (13 km hybrid analysis using 40 -km EnKF ensemble covariances) hybrid data assimilation experiments examining sensitivity to localization scales. With half and full ensemble covariance respectively, we tested two horizontal localization scales 192 km and 300 km, and two vertical localization scales 0.2 and 0.3 respectively. The experiment with full ensemble covariance and 192 km obtained the highest averaged precipitation skill scores. And with the same weighting factor, results using different vertical localization scales are comparable.

Additional information on RAP-related tasks

ESRL

GSD continues to make pgrb and bgrb files from the ESRL/GSD RAP-primary (RAPv2) real-time 1-h cycle available from its FTP site for users in NWS and other labs**.**

NCEP

NCEP maintained real-time availability of SAV and AHP guidance to all vendors from the operational hourly RAP on pressure surfaces via the NWS Family of Services (FOS) data feed and via the FAA Bulk Weather Data Telecommunications Gateway (FBWDTG). (EMC and NCO)

NCEP maintained real-time availability of full resolution gridded data from the operational RAP runs via anonymous ftp access via the NCEP server site at **ftp://ftpprd.ncep.noaa.gov/pub/data/nccf/com/rap/prod/** and at the NWS/OPS site at **ftp://tgftp.nws.noaa.gov/SL.us008001/ST.opnl/** in hourly directories named MT.rap_CY.00 through MT.rap_CY.23. This includes hourly BUFR soundings and output grids, which undergo no interpolation. Both sites now contain only grids in GRIB2 format **http://www.nco.ncep.noaa.gov/pmb/docs/GRIB1_to_GRIB2.shtml.** Gridded RAP and NARRE [-TL] fields are available on **NOMADS** for the CONUS domain on 13 km grid #130 and the Alaska domain on 11.25 km grid #242. RAP fields are also available for the larger North American domain on 32 km grid #221. A limited set of fields from the RAP runs (and other NCEP models) can also be viewed at **http://mag.ncep.noaa.gov** . (EMC&NCO)

Verification of RAP

ESRL's verification of the RAP is available from **http://ruc.noaa.gov/stats**. NCEP maintained its capability and provided access to routine verifications of the operational RAP analyses and forecasts. These include grid-to-station verifications versus rawinsonde, surface, aircraft, Profiler, and VAD data computed periodically at NCEP and accessible via NCEP's Mesoscale Modeling Branch website: **http://www.emc.ncep.noaa.gov/mmb/research/meso.verf.html** .

Deliverables	**Delivery Schedule**
Task 1 – Improve turbulence guidance from NWP forecasts	
a. Finalize code for RAPv2 for implementation at NCEP (ESRL, NCEP) • Vigorous effort leading complete package with extensive improvements, summary at: **http://ruc.noaa.gov/pdf/ESRLRAPHRRRchanges2013.pdf**	Mar 2013 **COMPLETE**

Deliverables	Delivery Schedule
b. Complete the testing of the 40/13 km dual-resolution hybrid DA system for RAP with 3-hourly cycles with conventional data (GSD, CAPS) • Initial work completed by CAPS, testing of further enhancements to system. GSD testing and inclusion in RAPv2 of hybrid system with full observational data, using GFS ensemble data. Milestones exceed.	Mar 2013 **COMPLETE**
d. Report on early version of RAPv3 primary cycle at GSD with physics enhancements for initialization of the HRRR. (ESRL) • Good progress with revised assimilation and WRFv3.5.1 as reported under Task 1. For more completeness, we request a delay to make this report by 30 January 2014.	**Delay to Jan 2014**
e. Report on options for including satellite data in the RAP ensemble hybrid data assimilation to ensure overall positive impacts of the data (NCEP, ESRL)	**Delay to Jan 2014**
f. Finalize RAP version to initialize experimental HRRR for 2014 real-time use toward operational HRRR (ESRL)	Mar 2014
g. Deliver progress report on development of NARRE (NCEP, ESRL)	Mar 2014
h. Deliver progress report on ensemble/hybrid data assimilation for use in NARRE (ESRL, NCEP)	Mar 2014
i. Subject to NCEP Directors' approval, upgrades to observation processing and/or quality control and/or GSI and/or NMMB systems become Operational at NCEP. (NCEP)	Mar 2014
j. Incorporate physics and dynamics improvements from the user community, GSD, and NCEP into WRF for use in the Rapid Refresh system. (NCAR-MMM)	Mar 2014

Task 2: Improve Quality of Convective Weather Forecasts from RAP, HRRR, NAM, NAM-nests and, eventually, NARRE and HRRRE

GSD

Substantial progress toward implementation of the HRRR at NCEP was made this quarter, with a complete set of codes transferred to EMC and run in test mode by Curtis Alexander. This will allow adaptation of the codes to NCEP standards and beginning of real-time parallel testing of the HRRR at EMC by Geoff Manikin, followed by transfer of the code and scripts to NCO. In addition, work by NCEP to make real-time 15 min. radar reflectivity data available (transfer of MRMS data from NSSL) on the WCOSS development machine, was quickly completed, overcoming a key obstacle for HRRR implementation.

Extensive testing of changes to both the RAP and HRRR data assimilation and model components (in both real-time parallel cycles and in retrospective tests) for the March 2013 internal code-freeze continues. This package will serve as a prototype for a RAPv3 with a likely implementation at NCEP in 2015. The first task was updates to latest community trunk versions of the GSI hybrid analysis and the WRF ARW model (3.5.1). Work with the model has focused evaluation of the updated Grell-Freitas cumulus parameterization relative to the existing Grell-based scheme, with an expectation that some calibration of scheme parameters would be necessary. First retrospective results confirmed this expectation, indicating a decrease in the amount of precipitation for higher thresholds over land. More recent tests, including modifications are showing more encouraging results.

Ming Hu has tested the latest version of the GSI (from the EMC trunk repository) and found the desired outcome of matched performance for a RAP application with matched input parameters. The new GSI formulation includes several upgrades that should be beneficial to the RAP, including improved satellite bias correction, and an updated community radiance transfer model (for the satellite radiance assimilation). Ming is now conducting test of the impact of varying key parameters in hybrid ensemble formulation. Increasing the ensemble weight to 75% was found to improve results, while increasing the covariance localization length scale was found to degrade the results. Tests continue toward finding an optimal set of parameters for the 2013 RAPv3 evaluation. Haidao Lin is testing the satellite radiance assimilation bias correction code, with plans to include this in the 2013 RAPv3

Several branch members traveled to NCEP in early December for the Production Suite Review (meetings between model developers and model users – mostly NWS centers and regional offices), and held many meetings to discuss modeling and data assimilation issues with EMC model developers. The GSD presentation on RAP/HRRR made at this meeting is available at **http://ruc.noaa.gov/pdf/NCEP_PSR_2013_RAP_FINAL_v5.pdf**. From these discussions, AMB personnel learned of many new community developments that benefit the RAP (including the satellite enhancements noted above and option for adjusting the covariance localization parameters in the GSI hybrid analysis). There was shared discussion on a wide variety of other topics including NARRE/HRRE development, 15-min radar data feed for reflectivity (for HRRR implementation) and radial velocity (likely will be included in the HRRR v2 implementation).

Patrick Hofmann has continued work on an AMB version of the Real-Time Mesoscale Analysis (RTMA) using the HRRR as a background. He now has hourly and 15-min versions of this running in real-time on Jet and grids from these analyses are being made available to outside users via the GSD ftp server. While at EMC for the NCEP Production Suite Review in early Dec., we held discussion Manual Pondeca and Steve Levine on optimizing parameter setting for the RTMA anisotropic analysis option within GSI.

NCEP

NCEP EMC and NCO conducted a planning exercise of what the modeling suite might look like on the Weather and Climate Operational Supercomputing System (WCOSS) Phase 1 (2013-2015) and Phase 2 (2015-2018).

NCEP & ESRL

The computing resources on NOAA R&D machine Zeus are being used by ESRL/GSD to run HRRR which together with the primary run on Jet comprise a 98.3% reliable source for HRRR.

Deliverables	**Delivery Schedule**
Task 2 – Improve Quality of Convective Weather Forecasts from RAP, HRRR, NAM, NAM-nests and, eventually, NARRE and HRRRE	
a. Report on initial tests of 3-km 15-min RTMA cloud / surface analysis for use in frontal diagnostics, CI assessment and other near-surface assessments (ESRL, NCEP) • *Good progress toward 3km RTMA and RUA surface and cloud analyses* • *Successful initial tests summarized in report:* **http://ruc.noaa.gov/pdf/GSD_RTMA_report.pdf**	Feb 2013 **COMPLETE**
b. Incorporate all assimilation and model changes that affect the HRRR into a frozen version of HRRR (and parent Rapid Refresh) for 2013 real-time use (ESRL) • *Extensive set of enhancements in place and running in real-time experimental GSD RAPv2 / HRRR system*	Mar 2013 **COMPLETE**
c. Provide preliminary 15-min RTMA surface analyses as experimental improved basis for frontal diagnostics and other diagnostics from surface analyses (ESRL,	Aug 2013

Deliverables	Delivery Schedule
NCEP) **Prototype HRRR-based 15-min RTMA analysis completed with sample grids and graphics.**	**COMPLETE**
d. Report on computing resource status on NCEP Central Computing System, NOAA R&D Site A and NOAA R&D Site B with regards to possible implementation of HRRR (NCEP, ESRL) See above discussion concerning ~2014 implementation and Task 4	**June 2013** **COMPLETE**
e. Complete FY13 internal assessment with revised 3-km HRRR running every hour (ESRL) **Assessment complete with very good results seen for 2013 HRRR in objective and subjective verification and high run reliability**	Sept 2013 **COMPLETE**
f. Provide revised 15-min RTMA surface analyses as primary basis for frontal diagnostics and other diagnostics from surface analyses for real-time use in 2014 (ESRL, NCEP). **Real-time 15-min RTMA running with grids available on ftp**	Feb 2014
g. Finalize all changes to the HRRR for real-time use in 2014 (ESRL)	Mar 2014

Task 3: Improve Quality of Icing Weather Forecasts from RAP, HRRR, NAM, NAM-nests and, eventually, NARRE and HRRRE

GSD

The RAPv2 physical parameterization configuration resulting from test and evaluation of physics options during the late 2012 – early 2013 period and described in previous reports will be part of the RAPv2 implementation currently scheduled for late February 2014:

- New 9-level configuration of the RUC land-surface model (RUC LSM) with fix to canopy evaporation when the MYNN surface layer is used.
- Mellor-Yamada-Nakanishi-Niino (MYNN) planetary-boundary- and surface-layer scheme (modified considerably by Joe Olson) in place of the Mellor-Yamada-Janjic (MYJ) scheme used in RAPv1.
- Continue use of the Grell G3 scheme from WRFv3.2.1.
- Continue use of the Goddard short wave and RRTM long-wave radiation schemes.
- Use WRFv3.4.1 version of the Thompson microphysics.

Ongoing and anticipated efforts toward improving all aspects of the physics over the next several months will result in significant changes for RAPv3. The status of this work is summarized in what follows.

- Likely replacement of RRTM longwave and Goddard shortwave radiation by the long and short wave versions of RRTMG. In addition to provision for attenuation of solar radiation by aerosol, RRTMG has a more rigorous accounting for the attenuation of solar radiation by ice and snow recently developed by Greg Thompson. Although RRTMG has available a semi-empirical diagnostic cloud fraction calculation, an alternative, being examined by Joe Olson, is direct coupling with the shallow convection component of the Grell-Freitas convection (see below).
- Further testing of candidate LSM and MYNN surface-layer changes. These include 1) treatment of albedo in situations of partial snow cover, which itself must be parameterized, 2) reduction of surface roughness in areas of snow cover over tundra, scrubland and cropland (earlier testing on this was mostly done with the MYJ PBL and surface layers; purpose is to reduce a cold bias in 2-m temperatures under very stable conditions), 3) further

consideration of the representation of snow melt in low-level warm-advection conditions typical of spring. A combination of retrospective experimentation and real-time evaluation this winter is underway; real-time evaluation of 2) clearly shows reduction of the cold bias over snow, but doesn't eliminate it.

- Further upgrades to the MYNN surface and boundary layer schemes. A primary goal of this work is to reduce the daytime warm and dry bias we see with the MYNN scheme under clear skies, particularly during the warm season. Because this warm / dry bias is likely a result of the interplay between the land-surface scheme, the surface and boundary-layer scheme and the parameterized convection, MYNN modifications must be tested together with the deep and shallow convection parameterization. Joe Olson has introduced some minor changes to the MYNN that decrease entrainment into the daytime mixed layer from above as part of an effort to mitigate the daytime warm and dry bias in the warm season. More importantly, Joe and Georg Grell developed an improvement to the treatment of shallow cumulus clouds, which is intended to address this issue. Evaluation of these changes is underway using the May-June 2013 retrospective period. The combination of RRTMG and the improved G-F scheme are showing promise, but further evaluation is pending.
- More rational usage of 2-m dew-point observations in the GSI analysis. Currently, the specific humidity at 2m (derived from the 2-m dew points) is compared directly with the 1-h forecast of specific humidity at the lowest model level (about 8m AGL) to obtain the observation innovation used in the analysis. Because there can be a substantial downward gradient in moisture at low levels, failure to account for the height difference between observation and first model level is likely giving erroneous specific-humidity innovations in the analysis. A procedure to adjust the lowest-model-layer moisture and temperature to 2 m using similarity theory before computing the innovation, and then applying those innovations at the lowest model layer during the analysis will be tested in the near future.
- Possible replacement of the G3 convection scheme used in RAPv1 and RAPv2 by the Grell-Freitas deep and shallow scheme. Georg Grell has continued to improve the G-F deep convection scheme. During the quarter, a major bug fix plus some tuning to increase the amount of convective precipitation have brought the G-F scheme to at least the level of skill of the WRFv3.2.1 G3 scheme currently in the operational RAPv1 and slated for continued use in RAPv2. Further confirmatory retrospective testing will be required, but it now appears that the G-F is a strong candidate to replace the G3 scheme in the prototype RAPv3. Use of only the shallow portion of G-F will be considered for HRRR application, pending successful testing during the Jan-Mar 2014 quarter.
- Testing of changes to the Thompson microphysics for WRFv3.5.1. We anticipate these will mainly impact higher rainfall rates and therefore may be of importance for the HRRR configuration in 2014. Evaluation in HRRR has not yet begun.
- New aerosol-aware microphysics from NCAR. Pending NCAR's preparing the code for transfer to GSD (see item a. under table of Task 3 deliverables below), test and evaluation will begin by GSD. This is a potential major change and will require careful evaluation. In preparation for this, GSD met with Greg Thompson of NCAR on 15 Nov to plan some details on this transfer. We anticipate significant testing of the aerosol-aware microphysics in 2014 toward implementation in the March 2015 ESRL versions of the RAP and HRRR.

NCEP

With the HRRR prediction model running fairly efficiently, NCEP is awaiting the remainder of the HRRR system containing initialization, post-processing and product generation components which must all fit into the allocated space and complete each run within an hour.

NCAR/RAL

CURRENT EFFORTS: In the month of December, G. Thompson worked jointly with NCAR-MMM's D. Gill to finalize the transfer of the new aerosol-aware Thompson & Eidhammer (2013) microphysics code changes into the WRF code repository. The integration involved many code modules as well as changes to WPS-formatted aerosol input data and is very nearly completed. Also, the journal manuscript by G. Thompson and T. Eidhammer was revised based on reviewer comments and re-submitted to J. Atmos. Sci (AMS).

FUTURE EFFORTS: NCAR-RAL will assist NOAA-GSD to adopt/utilize the new scheme. NCAR-RAL and NOAA-GSD still need to plan and carry out a method to link aerosols/species found in WRF-RAP-Chem to simplify into those variables used by the new microphysics scheme; or, alternatively, use with built-in climatological aerosols.

PROBLEMS/ISSUES ENCOUNTERED: The integration of the aerosol-aware microphysics scheme depends on availability of NOAA-GSD and NCAR-MMM personnel and a timeline of activities has not yet been decided.

INTERFACE WITH OTHER ORGANIZATIONS: David Gill and Michael Duda, NCAR-MMM

NCAR/MMM

Deliver a WRF Users' Workshop and WRF Tutorial for the User Community

NCAR gave a WRF tutorial in York, UK on October 8–11. This was part of the NCAR–NCAS (National Centre for Atmospheric Science) 2013 Workshop and Tutorial. This tutorial covered the basic WRF system and WRF-Chem. Approximately 60 people attended.

MMM began organizing the next WRF tutorial at NCAR on January 22–31, 2014. This will present a basic WRF tutorial, a WRF/DART ensemble DA tutorial, and a MET (Model Evaluation Tools) tutorial.

PLANNED EFFORTS: Tutorial scheduled for January 2014. NCAR will begin the planning of the 2014 WRF Users' Workshop in FY14Q2.

UPDATES TO SCHEDULE: NONE

Incorporate Physics and Dynamics Improvements into WRF

NCAR led the oversight of preparations of the next major release, WRF V3.6. Regular meetings of the Release Committee were held at NCAR. The WRF code was frozen in December in preparation for the release. The V3.6 release will be in Spring 2014, and details on it may be found at: **http://wrf-model.org/users/release.php**.

A new microphysics scheme for WRF is being prepared V3.6, the Spectral Bin Microphysics (SBM) scheme. Jimy Dudhia (NCAR/MMM) obtained this from Barry Lynn and Alex Khain (Hebrew University of Jerusalem). Initial testing of the package has been done, and Ming Chen (NCAR/MMM) and Dudhia have been improving aspects of the coding and tracking parallelism problems in preparation for the scheme's release.

Dudhia worked with Greg Thompson (NCAR/RAL) as part of the WRF-Solar project. Thompson has a new aerosol representation for microphysics, and the goal is to have it interact with WRF radiation packages.

Dudhia modified the WRF diffusion option to follow theory better, based on a suggestion by Rich Rotunno (NCAR/MMM). The modification was a minor change to the coefficient for the vertical diffusion of vertical momentum, and the effect on results is small. The revision will appear in the V3.6 release.

Dudhia worked with Jose Arias (Univ. of Jaen, Spain) to correct a problem with CAM radiation used with new solar outputs (diffuse/direct) that he has implemented. This issue was related to inconsistent zenith angles in two parts of the code. Dudhia and Arias also finalized the aerosol input capability for the RRTMG and Goddard SW radiation schemes. This allows use of aerosol information to provide better total, direct, and diffuse solar fluxes at the surface. Lastly, Dudhia and Arias worked on a shortwave surface interpolation method for a smoother variation between time steps. The goal is to account for rapid cloud changes using a statistical fit to integrated liquid-water path as part of the interpolation.

Dudhia developed a PBL mixing approach for scalars and tracers, using the WRF PBL K-coefficient profile to mix these in a new part of the PBL driver. This allows scalars and tracers to be mixed consistently with the variables mixed in any of the PBL schemes, whereas previously these fields would not be vertically mixed when a PBL scheme was used. The code has been finalized and will be released in V3.6.

Dudhia developed code to make diff_opt=3 (truly horizontal diffusion) work in complex terrain. The modifications decrease the strength of mixing when terrain becomes too steep to provide a good gradient, and they increase code stability. Dudhia also finalized code for horizontal diffusion (diff_opt=2) in complex terrain. This has the benefit of not producing mixing up slopes, which has been shown to be detrimental in some situations, and the modification allows the scheme to remain stable for moderate slopes. This code was committed to the repository and will be in V3.6.

Dudhia worked with visitors Pedro Jimenez (CIEMAT, Spain) and Raquel Lorente (Univ. of Murcia, Spain) to improve WRF's topo_wind option for the diurnal cycle. The goal is to reduce the topo_wind effect in daytime convective PBLs, where there was a low wind speed bias due to the option's enhanced frictional effect. The modifications have been finalized. In a related improvement, Jimenez's diagnostic TKE and length scales are being considered to help in determining mixing regime.

Ming Chen (NCAR/MMM), Changhai Liu (NCAR/RAL), and visitor Feng Chen (Zhejiang Meteorological Bureau evaluated the CLM LSM in WRF at 4-km grid size over complex terrain. To reduce the cost of the CLM scheme, they configured it to be called less frequently than at every time step.

PLANNED EFFORTS: The development and incorporation of new physics and dynamics for WRF for the RAP and HRRR will continue into the next quarter.

UPDATES TO SCHEDULE: NONE

Deliverables	**Delivery Schedule**
Task 3 – Improve Quality of Icing Weather Forecasts from RAP, HRRR, NAM, NAM-nests and, eventually, NARRE and HRRRE	**Delivery Schedule**
a. Conduct initial single test of aerosol-aware microphysics in ARW in a RAP configuration as start of a 2014 evaluation for its suitability as part of the RAPv3 prototype for 2015 NCEP implementation (NCAR-RAL, ESRL) • This task name has been changed to accurately reflect the long-term evaluation needed for this complicated change over much of 2014.	Feb 2014. Task name changed.
b. Final model physics code transfer complete to EMC for Rapid Refresh 2 upgrade change package to be implemented at NCEP by spring 2014 (ESRL, NCEP) • Freeze of model physics code for March 2013 version of RAP at ESRL allows this milestone to be met.	Mar 2013 **COMPLETE**
c. Pending NCEP computer readiness and EMC and NCEP Center initial recommendations, Requests for Change (RFCs) are filed to submit WRF physics code changes as part of upgrade for Rapid Refresh v2 software to NCO (NCEP, ESRL)	**Sept 2013** **COMPLETE**
d. Transfer upgraded coupled aerosol-microphysics scheme into a test version of HRRR (NCAR-MMM, ESRL)	Dec 2013
f. Finalize microphysics changes and other physics changes to improve icing forecasts for ESRL version of RAP and HRRR for 2014 real-time use (ESRL)	Mar 2014
g. Report summary of icing probability skill measures by quarter for the year. (NCEP)	Mar 2014

Task 4: Develop convection-ATM-specific improvements for guidance from the HRRR (and later, HRRRE) and interact with CoSPA (or other) program partner labs and the FAA

Task 4 – Complete implementation of new microphysics for associated reflectivity echo-top diagnostics for 2013 real-time use (ESRL)

Current:

A new retrospective period from 15-31 May 2013 has been established to begin evaluation of model and data assimilation changes for the 2014 version of the ESRL RAP and HRRR. A control run for the retrospective period has been completed using the 2013 ESRL RAP and HRRR versions but also include an adjustment in soil temperature and moisture and a correction in the RUC land surface model to remove unrealistic surface evaporation flux in areas of precipitation that were not available during the real-time runs in early May 2013. The code for the WRF-ARW version 3.5.1 update including changes to the Thompson microphysics scheme and associated reflectivity, VIL and echo top diagnostics has been merged with the ESRL RAP and HRRR WRF-ARW code base. An initial RAP retrospective runs with WRF-ARW version 3.5.1 have been completed for the May 2013 period along with an upper-level and surface forecast verification comparison to the control run. The experiments include new convective parameterization and radiation schemes and updates to the boundary layer and land-surface schemes with forecast improvements noted in the initial results when compared to the control run.

Transition to the new format radar reflectivity data feed from NSSL for both the ESRL RAP and HRRR radar data assimilation was completed in December and all dependencies on the legacy feed of the radar reflectivity data have been removed.

Planned:

Evaluation of additional ESRL RAP and HRRR model and data assimilation changes will be conduced using the 15-31 May 2013 retrospective period. Once the RAP changes are determined, HRRR retrospective runs will be executed including an evaluation of the latest Thompson microphysics scheme in WRF-ARW version 3.5.1 along with testing and calibration of the associated reflectivity, VIL and echo top diagnostics for 2014 configurations of the ESRL RAP and HRRR.

Task 4 – Assess HRRR reliability and provide monthly reporting (ESRL)

HRRR Reliability for 0-8 Hour VIL/Echo Tops for October 2013

Jet
All runs: 88.2%
3 or more consecutive missed runs: 95.4% (most meaningful for CoSPA)
6 or more consecutive missed runs: 98.5%
8 outages of at least 3 hrs. or longer
5 outages of at least 6 hrs. or longer

Zeus
All runs: 72.0%
3 or more consecutive missed runs: 76.6% (most meaningful for CoSPA)
6 or more consecutive missed runs: 79.6%
9 outages of at least 3 hrs. or longer
5 outages of at least 6 hrs. or longer

Combined (Jet or Zeus)
All runs: 92.6%
3 or more consecutive missed runs: 96.6% (most meaningful for CoSPA)
6 or more consecutive missed runs: 98.8%
6 outages of at least 3 hrs. or longer

HRRR Reliability for 0-8 Hour VIL/Echo Tops for November 2013

Jet
All runs: 88.3%
3 or more consecutive missed runs: 97.4% (most meaningful for CoSPA)
6 or more consecutive missed runs: 98.9%
5 outages of at least 3 hrs. or longer
3 outages of at least 6 hrs. or longer

Zeus
All runs: 67.1%
3 or more consecutive missed runs: 75.0% (most meaningful for CoSPA)
6 or more consecutive missed runs: 81.9%
19 outages of at least 3 hrs. or longer
14 outages of at least 6 hrs. or longer

Combined (Jet or Zeus)
All runs: 95.8%
3 or more consecutive missed runs: 99.6% (most meaningful for CoSPA)
6 or more consecutive missed runs: 100.0%
2 outages of at least 3 hrs. or longer
0 outages of at least 6 hrs. or longer

HRRR Reliability for 0-8 Hour VIL/Echo Tops for December 2013

Jet
All runs: 86.3%
3 or more consecutive missed runs: 97.3% (most meaningful for CoSPA)
6 or more consecutive missed runs: 99.7%
10 outages of at least 3 hrs. or longer
2 outages of at least 6 hrs. or longer

Zeus
All runs: 78.5%
3 or more consecutive missed runs: 84.9% (most meaningful for CoSPA)
6 or more consecutive missed runs: 88.8%
12 outages of at least 3 hrs. or longer
8 outages of at least 6 hrs. or longer

Combined (Jet or Zeus)
All runs: 97.3%
3 or more consecutive missed runs: 100.0% (most meaningful for CoSPA)
6 or more consecutive missed runs: 100.0%
0 outages of at least 3 hrs. or longer
0 outages of at least 6 hrs. or longer

Under Task 4 – Complete implementation of refined cloud-top cooling (SatCast) assimilation for HRRR for real-time use in 2014

Tracy Smith continued her work with the assimilation of GOES-CI cloud-top cooling radar data within the RAP. Following her initial experiments she has completed an additional retrospective experiment using a higher cooling rate threshold and successfully removed some of the false alarms (see Fig. 1 below), resulting in slight higher skill scores. Additional experiments are ongoing.

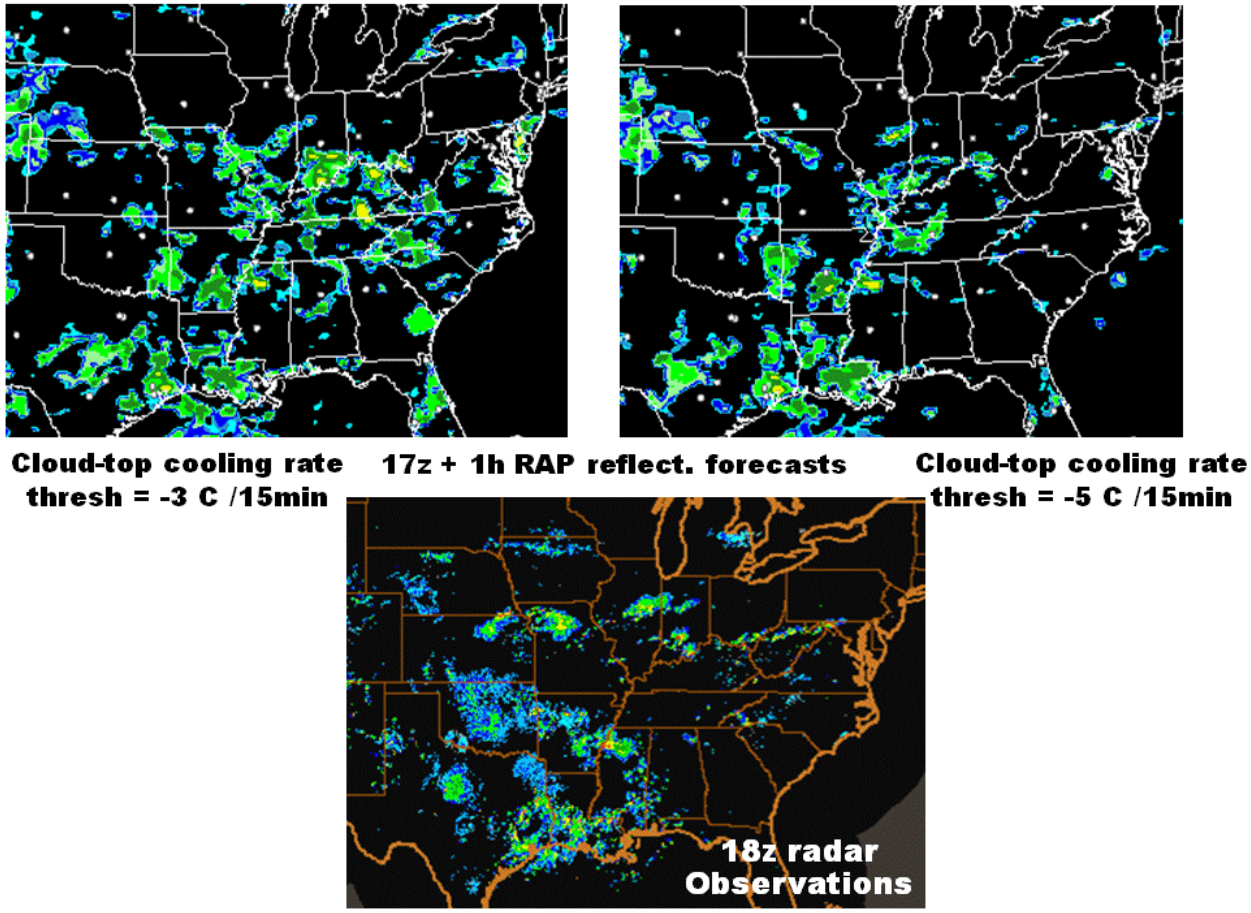

Fig. 1, Comparison of RAP 1-h forecasts valid 18z 8 July 2012 with assimilation of satellite-based cloud-top cooling rate data using a minimum threshold a -3 deg. C per 15 min. (left) and -5 deg. C per 15 min (right). Comparison with the radar observations (bottom) illustrates the reduction in spurious convection associated with the more restrictive -5 deg. threshold (right).

Also Under Task 4 – Interact with CoSPA (or other) program partner labs and the FAA

Team (ESRL/GSD, NCAR/RAL, and MIT/LL) telecons and e-mail correspondence took place in October to discuss issues related to the HRRR reliability including scheduled outage periods during the CoSPA 2013 season. A discussion with NCAR/RAL to resolve an infrequent problem in blending the HRRR for CoSPA due to missing forecast lead times was conducted in October and the problem was resolved in the HRRR post-processing at ESRL/GSD. Team telecons and e-mail correspondence will continue to occur during the CoSPA offseason regarding upcoming HRRR changes. Discussion with MIT/LL continues regarding possible collaboration on convective weather avoidance polygons including the potential for feedback on the evolution of the size distribution of forecasted convective structures in the HRRR.

Deliverables	Delivery Schedule
Task 4 – Develop convection-ATM-specific improvements to guidance from the HRRR (and later, HRRRE) and interact with CoSPA (or other) program partner labs and the FAA	
Complete implementation of new microphysics for associated reflectivity echo-top diagnostics for 2013 real-time use (ESRL) • Code for revised echo-top / reflectivity diagnostics with revised microphysics implemented in GSD real-time HRRR.	Mar 2013 **COMPLETE**
Conduct baseline testing of the early 2013 HRRR version (ESRL) • Baseline testing of 2013 HRRR version completed as part of code preparation for freeze. Summary of skill score improvements being prepared.	Mar 2013 **COMPLETE**
Report on evaluation of new microphysics scheme and associated echo-top and reflectivity diagnostics in ESRL/GSD RAP and HRRR (ESRL) • *Preliminary evaluation completed and summarized in report:* **http://ruc.noaa.gov/pdf/GSD_reflectivity_report.pdf**	Mar 2013 **COMPLETE**
Assess HRRR reliability and provide monthly reporting (ESRL) Reliability statistics are being reported each month	*Apr 2013* **COMPLETE** *(ongoing)*
Report on evaluation of revised WRFv3.4 microphysics for RAP/HRRR for its effects on echo-top and reflectivity in ESRL RAP/HRRR (ESRL)	Mar 2014
Complete implementation of new microphysics for associated reflectivity echo-top diagnostics for 2014 real-time use of HRRR (ESRL)	Mar 2014
Complete implementation of refined SatCast assimilation for HRRR for real-time use in 2014 (ESRL) **Evaluation of preliminary results**	Mar 2014 **Good progress**
Report on 2014 baseline testing of the HRRR (ESRL)	Mar 2014